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AUTHOR	Eilers, Rebecca E.; Oller, D. Kimbrough
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ABSTRACT

This study investigated the relationship between perception and production in children's phonological learning to determine whether perceptual confusions could account for the patterns of substitution and deletion found in 2-year-olds' speech. A total of 14 children were presented pairs of toy stimuli, with each pair composed of a familiar item and an unfamiliar nonsense toy. The names of the toys in each pair differed from each other by one or two phonological features. The children were asked individually to name the toys both imitatively and spontaneously and to perform a task that tested whether they could discriminate the two names when the experimenter produced them. The methodology used is recommended in the study of developmental perceptual confusions of speech sounds in children at this age since it is easily administered and scored and can be presented by live-voice without substantial loss of data validity. The data suggest that some minimal pairs of phonemes are easily discriminated by most 24-month-old children, but others are more difficult. Elements which are substituted for each other in childhood speech production are not necessarily the most difficult contrasts to perceive; perceptual confusions probably play a substantial part in childhood speech errors but not all errors are related to perceptual difficulties. (GO)

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THE ROLE OF SPEECH DISCRIMINATION IN DEVELOPMENTAL SOUND SUBSTITUTIONS

Rebecca E. Eilers
Child Development and Mental
Retardation Center
University of Washington
Seattle, Washington

and

D. Kimbrough Oller
Child Development and Mental
Retardation Center
University of Washington
Seattle, Washington

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ABSTRACT

Fourteen two-year olds were presented with minimal word pairs in a new and highly successful experimental perception paradigm. The study focusses on perception of some contrasts which are actualized and some which are not actualized in child productions. The data suggest that perceptual difficulties probably play a substantial role in some childhood speech errors, but little, if any, role in others.

Lately, much emphasis has been placed on the relationships between the comprehension and production of syntactic structures by children learning a first language. However, the relationship between perception and production has been little studied in the area of phonological learning by children. The dearth of knowledge in this area does not, however, reflect lack of interest but rather reflects the difficulty investigators encounter when appealing to infants and young children for same-different judgements about phonetic features. In recent years, experimenters (Eilers and Minifie, 1975; Eimas, Siqueland, Jusczyki, and Vigorito, 1971; Morse, 1972; Trehub and Rabinovitch, 1972; and Moffit, 1971) have had considerable success in investigating and describing early speech discrimination abilities of infants (not yet four months of age). However, from age four months to three years appropriate methodologies are either unavailable, unreliable or extremely time consuming (Edwards, 1974; Garnica, 1971; Schvachkin, 1973).

The methodology employed here, a modification of one described by Vincent-Smith, Bricker and Bricker (1974) for studying receptive vocabulary acquisition, has been used successfully to study speech discrimination with children as young as sixteen months. In most instances, we have been able to collect discrimination data on ten minimal phonological contrasts in fewer than three half-hour laboratory sessions. We feel confident that this technique provides a basis for research on the role of perceptual confusion in child speech.

For sometime now, considerable information concerning the nature of sound substitutions in childhood speech production has been available. Many independent investigators (from Schleicher, 1865, and Schultze, 1880 through Ingram, 1971, Oller, 1974, and Ferguson, 1973) have reported certain consistent patterns of substitution and deletion normally found during the course of phonological development. For instance, during the second and third year of life, children normally

change liquid consonants (r and l) to [w], so that [rɪbɪt] is normally produced with an initial [w]-like element instead of [r]. Similarly, children normally "deaspirate" initial stop consonants so that the initial [k^h] in [k^har] ("car") becomes [k]. The forces underlying such consistent patterns of substitution are not well-understood. Several hypotheses concerning these forces can be proposed. Among them are: 1) substitutions are motivated by perceptual confusions; 2) substitutions are motivated by neuro-muscular motor constraints; and 3) substitutions are motivated by an interaction of perceptual and motor constraints. It is obvious, of course, that this list is not exhaustive and can be expanded to include other factors such as "organizational" processes involved in lexical storage (Ingram, in press).

The following experiment was designed to help isolate possible perceptual motivations for the phonological structure of early child language. Specifically, we wished to determine whether perceptual confusions could account, at least in part, for the patterns of substitution and deletion found in two-year-old speech.

METHOD.

Stimuli

Several types of stimulus pairs were constructed for a perception experiment. They are listed in Table 1. Type 1 stimuli included pairs of phonetic elements normally in substitution relationship in twenty-four-month-old speech. (For instance, most twenty-four-month olds collapse [k] and [k^h] into a single productive category [k]; [r] and [w] merge to [w], etc.) Type 2 stimuli included pairs of phonetic elements not normally in substitution relationship. The members of the Type 1 and Type 2 pairs differed from one another in an analogous fashion, i.e., each item differed from its paired item by just one phonological feature. A Type 3 contrast where more than one phonological feature differentiated the members of the pair was included as a control item to insure the children

understood the task. The members of this pair are not usually found in substitution relationship in child speech. We reasoned that if substitution processes reflect perceptual confusions Type 3 and 2 items should have fewer errors than Type 1 items.

Insert Table 1

Procedure

The following task was designed to assess discriminability of the stimulus items listed in Table 1. During experimental trials, children were presented with two toy objects, one real item familiar to the child, e.g., "car" [k^har] and one unfamiliar nonsense toy labelled [kar]. The child was encouraged to play with the toys, name them both imitatively and spontaneously and to perform some actions with the two objects. After this warm-up period, each object was placed on top of a closed container. One container held a nutritive reinforcer. The children were taught that the experimenter would tell them where the candy was--e.g., "It's under the [k^har]." If the child responded by choosing the named item, he was given the candy. If he chose incorrectly, he was asked to try the next presentation and to listen carefully. Each stimulus pair was presented eight times. During four of these presentations, the real object was the correct choice and for the other four the nonsense object was correct. Within these restrictions, stimuli were counterbalanced for position. Order of presentation of stimuli was randomized. These controls were necessary to avoid data bias as a result of hand or object preference. Scoring was done from an adjoining control room. At least seven correct out of eight trials was considered strong evidence of discriminability. Six out of eight was considered probable discrimination, especially if the child momentarily lost attention during the error trials.

Before the experimental trials, the children had to reach a training criterion (four in a row correct) on non-minimal pairs like "horse" - "dog." Eighty percent

of the two-year olds completed the training and some of the eight-item experimental tasks during the first 30- to 45-minute session. On the average, each child came to our labs for three initial visits during a one-month period. Ten children were brought back three and one-half months later for a test-retest reliability study and for a study of whether or not earlier results had been influenced by live-voice presentation of extraneous cues. For these later visits, three of the contrast pairs (one Type 1 pair, one Type 2 pair and the Type 3 pair) were presented via tape recorder. The recorded stimulus pairs consisted of tokens matched on fundamental frequency, loudness and duration. For the taped presentation, only the critical phonetic features were allowed to vary normally.

Subjects

Subjects were 14 children between the ages of twenty-two and twenty-six months: mean age twenty-four months. All children were recruited through mail solicitation. Ten of the 14 children were seen for the second series of visits approximately three and one-half months after the first series. The other four children were not available for retesting.

RESULTS AND DISCUSSION

Procedural Reliability -- Tape Recorded Versus Live Speech

For reliability purposes, ten children were presented with three stimulus pairs, one from each of the three categories--once by live voice and three and one-half months later by tape-recorder. The results of this procedure are presented in Table 2. Notice that scores increase slightly with tape-recorder

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Insert Table 2

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presentation, with the largest gain for the pair $[p^h ɪg-t^h ɪg]$. None of the changes, however, were significant. Since most of the children participating in this aspect of the study were seen over a three and one-half-month interval, learning could account for the increased scores. Since, with the exception of one pair for one child, no eight-trial test score decreased by more than one incorrect trial when presented by the tape recorder, we can feel confident that live-voice presentation was not providing extraneous cues and thus inflating evidence of discriminability.

Ease of Perception of Type 1 Stimuli Versus Type 2

Relative difficulty of the three types of stimuli was ascertained using Duncan's New Multiple Range Test applied to the differences between the nine stimulus pair means. The stimuli fell statistically into three difficulty groupings. These results are shown in Table 3. Difficulty Group A consists of stimuli with least frequent perceptual errors, Group B consists of stimuli

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Insert Table 3

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intermediate in difficulty and, finally, Group C consists of stimuli with the most frequent perceptual errors. Also note that $[p^h ɪg]$-$[t^h ɪg]$ falls midway between Group A and B. If we now look at the stimulus difficulty ordering for perceptual ease in terms of the hypothesis that Type 3 and Type 2 stimuli will be perceptuallyconfused less frequently than the Type 1 stimuli, we find that the hypothesis is only partly verified. The pair $[k^h ow]$-$[pow]$, the Type 3 stimulus, was the most discriminable, presumably for at least two reasons: 1) the members of the pair differ from one another on at least two phonological features (aspiration and place of articulation); 2) $[k^h]$ and $[p]$ are not normally in substitution relationship in child speech.

However, Type 1 stimuli, contrary to the hypothesis, distributed themselves in difficulty across Groups A,B and C that is, some contrasts which were in substitution relationship in the child's speech (Type 1) were easily discriminable by most children (i.e., [k^har]-[kar]); other contrasts which were in substitution relationship were not discriminated by any of the children ([fɪ]-[θɪ] or [mʌki]-[mʌ̃ŋki]). Furthermore, some items not normally in substitution relationship (Type 2) proved more difficult to discriminate than some Type 1 items (e.g., [plɔk]-[lɔk] was more difficult than [k^har]-[kar]).

Relationships between Perception and Production

During the course of collecting the perception data, we transcribed the children's attempts to produce both members of the contrastive pairs. In order to receive credit for correct production (+ production), the child had to imitate both the nonsense word and real object word in such a way as to maintain some clear phonetic contrast. In order to receive credit for correct perception (+ perception), the child had to meet the aforementioned criteria for a pair on the perceptual task (see Procedures section). The combined perception/production scores are presented in Table 4 for the children's first visit and in Table 5 for the second visit. Each data point is placed in one of four categories: +perception/+production; +perception/-production; -perception/-production and -perception/+production.

Insert Tables 4 and 5

In looking at scores across the four perception/production categories, it is obvious that the distribution is different for Type 1 and Type 2 stimuli. As expected for Type 1 stimuli, most scores fall in either the +perception/-production category or in the -perception/-production category. This confirms the prediction that the phonetic categories in the pre-selected Type 1 stimuli were generally collapsed in production by the two-year olds in this study. In contrast, the Type 2 stimuli fell largely into the +perception/+production category. As predicted,

children maintained the crucial production contrasts on Type 2 stimuli. In violation of our expectations, however, some scores on Type 2 stimuli fell in the - perception/+production category. Five out of 14 children produced a contrast for the pair [p^hɪg]-[t^hɪg] while failing the perception task on this contrast. Two out of twelve did the same for the other Type 2 stimulus pair [pl̥ɔk]-[l̥ɔk]. All of these children succeeded on the perception task for other Type 1 or Type 2 pairs.

Data of this sort have been reported by Edwards (1974) for normal children and Menyuk (personal communication, 1975) for language-delayed children. Edwards interprets these data to suggest that in "rare instances production apparently precedes perception." However, to maintain that these are instances of production preceding perception obscures the fact that some aspect of the difference between the crucial consonants must be perceived before the child can imitate the members of the consonant pair differently and accurately.

The data show that children sometimes imitatively produce a contrast (and, therefore, they must perceive it at some level) but fail on a more abstract perceptual task that requires that the child assign different meaning to the two members of the contrasted pair. Why is it that the child fails to employ fully the contrast he can easily produce and, at a peripheral level, that he can easily hear? At least a partial answer to this question might come from considering this issue from a different point of view. We might well ask instead --why does the child succeed on the abstract perceptual task on contrasts which are so productively difficult that they are not actualized even in imitation (e.g., k^har-kar)? One possible explanation involves the child's tacit awareness of correspondences between adult and child phonology. Suppose the child is aware that he has collapsed categories which are separate in adult speech (e.g., [k^h] → [k]). Perhaps the child's special awareness of these

correspondences makes him more sensitive in abstract processing of these potentially-confused pairs than he would be in processing categories in which the correspondences between adult and child phonetic elements is simply one to one (such as $t^h \rightarrow t^h$, $p^h \rightarrow p^h$). The special pressures that the task imposes on the child, i.e., learning the name of a new toy which happens to sound a great deal like the name of a familiar toy, may serve to amplify the process of extra sensitization.

We recognize the speculative nature of this discussion. It is clear that further investigation is necessary to either support or refute the notion of sensitization. In fact, further research seems necessary to suggest alternative explanations.

The Relative Contribution of Perception and Production Factors in Childhood Sound Substitutions

In this paper, evidence has been presented to suggest that some phonological discriminations are harder for children than others. The question remains--how much and in what way does phonological confusion in perception contribute to the nature of the sound substitutions? While it is clear that perceptual confusions contribute to the nature of substitutions in child speech production, they cannot explain why substitutions are unidirectional, i.e., they cannot explain why one of two phonetic alternatives is consistently employed in place of both (or all) elements of a class. In fact, Compton (1971) has suggested that the mark of a perceptual problem in childhood speech errors is "bidirectionality" of substitutions--e.g., A produced as A or B, and B also produced as A or B. This sort of pattern is relatively atypical. Consider a more characteristic unidirectional pattern, as normally occurs in the child's treatment of [f] and [θ]. In production, no child in our study was observed to produce [θ] spontaneously in substitution for [f] while virtually all attempted [θ]'s were replaced by [f].

in perception, no child was able to demonstrate discrimination of [f] from [θ]. Yet to conclude that [θ] does not appear in child production because of the perceptual confusion would be inappropriate. The perceptual confusion only explains the alternation between the two elements. It cannot determine which of the three possible alternation patterns (1. [θ] → [f]; 2. [f] → [θ]; and 3. [f] → [θ], [f] and [θ] → [θ], [f]) actually occurs. The fact that two-year-old children normally use (1) rather than (2) or (3) seems most reasonably accounted for by a relative ease of production of [f].*

A systematic analysis of productive and perceptual constraints of other potentially-confused consonant pairs will probably reveal other instances in which perception, production and other factors operate in concert to determine the forms of early child speech.

CONCLUSIONS

A task has been devised to study developmental perceptual confusions of speech sounds in children at least as young as twenty-four months. The task is easily administered and scored and requires relatively few laboratory visits. Furthermore, the task can be presented by live-voice without substantial loss of data validity.

Our data strongly suggest that some minimal pairs of phonemes are easily discriminable by most twenty-four-month-old children. Other minimal phonemic pairs are much more difficult. It is not true, however, that elements which are

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* It should be pointed out that somewhat older children do seem to use patterns (2) and/or (3) during a brief transition period, after which the apparent restrictions against [θ] are mastered. This sort of "process reversal" or "rule inversion" has been described as a hypercorrection or overgeneralization of a newly-learned element.

substituted for each other in childhood speech production are necessarily the most difficult contrasts to perceive. The data lead us to the conclusion that perceptual confusions probably play a substantial part in childhood speech errors but that not all errors are related to perceptual difficulties. We envision a characterization of the child's phonological system which incorporates a hierarchy of discrimination difficulty for the various phonological sequences of the language being learned. This hierarchy should help specify the extent to which perceptual confusions influence the nature of childhood speech errors.

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TABLE 1

Stimulus Pairs, Their Most Common Two-Year-Old Production and Categorization by Childhood Process

	Stimuli	"Gloss"	Most Common Childhood Pronunciation	Child Processes
Type 1	k^{h}ar - kar	"car"	ka(r) - ka(r)	deaspiration (liquidation)
	plɔk - pɔk	"block"	pɔk - pɔk	cluster simplification-liquidation
	mʌki - mʌ̃ŋki	"monkey"	mʌki - mʌki	cluster simplification-denasalization
	fɪʃ - θɪʃ	"fish"	fɪs - fɪs	substitution θ → f, fronting
	ræbɪt - wæbɪt	"rabbit"	wæbɪt - wæbɪt	liquidation
Type 2	p^{h}ɪg - t^{h}ɪg	"pig"	pɪ(k) - tɪ(k)*	deaspiration (final devoicing)
	plɔk - lɔk	"block"	pɔk - wɔk*	cluster reduction, liquidation
Type 3	k^{h}ow - pow	"cow"	kow - pow*	deaspiration

*crucial contrast maintained in child's speech

TABLE 2

Mean Number of Correct Trials Attained by Nine Children on Three Test Items When Presented by Live Voice and by Tape-Recorder. (Total Possible = 8)

Stimulis Pair	Live Voice	Tape Recorder	t	df
1. kar - k^har	7.1	6.9	.36	18
2. t^hɪg - p^hɪg	6.2	7.2	1.56	18
3. pow - k^how	7.1	7.4	.45	18

TABLE 3

Stimulus Pairs, Mean Score and Difficulty Determined by Duncans Test for Eleven Subjects Completing All Stimuli (Total Possible = 8.0)

Difficulty Level	Pair	Mean
A	kʰow - pow	7.2
	kʰar - kar	7.18
	pʰɪg - tʰɪg	7.0
B	pʰɪg - tʰɪg	7.0
	plɔk - lɔk	6.09
	plɔk - pɔk	5.82
	ræbɪt - wæbɪt	5.70
C	mʌki - mʌ̃ŋki	4.00
	fɪʃ - θɪʃ	3.44

TABLE 4

Visit One -- Comparison of Perception and Production Data

Contrast	#Children	1 +Percep /+Prod	2 +Percep/-Prod	3 -Percep/-Prod	4 -Percep/+Prod
Type I					
kʰar - kar	14	3	9	2	0
plɔk - pɔk	12	2	5	5	0
ræbɪt - wæbɪt	10	1	5	4	0
mʌ̃ŋki - mʌki	10	0	2	8	0
fɪʃ - θɪʃ	10	0	0	9	1*
Type II					
pʰɪg - tʰɪg	14	7	0	2	5
plɔk - lɔk	12	10	0	0	2
Type III					
kʰow - pow	14	14	0	0	0

*unstable production--weak evidence

TABLE 5

Visit 2

Contrast	#Children	1 +Percep/+Prod	2 +Percep/-Prod	3 -Percep/-Prod	4 -Percep/+Prod
Type I					
**k^har - kar	10	$6^{(+/-)}$	$3^{(+/-)}$	0	$1^{*(+/+)}$
plɔk - pɔk	2	$1^{(-/-)}$	0	$1^{(-1-)}$	
ræbɪt - wæbɪt	3	0	3 (2-/-) (1+/-)	0	0
mʌŋki-mʌki	6	1	$1^{(-/-)}$	$4^{(-/-)}$	0
fɪʃ - θɪʃ	2	0	0	$2^{(-/-)}$	0
Type II					
**p^hɪg - t^hɪg	10	10 (7+/+) (2-/+) (1-/-)	0	0	0
plɔk - lɔk	0	———	———	———	———
Type III					
**k^how - pow	10	10	0	0	0

( ) indicate child's or children's perception/production status at previous visit.

* unstable production--weak evidence

** tape recorder presentation for Visit Two